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(54) **TRANSFER DEVICE, AND TRANSFER METHOD**

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**H04L 12/911** (2013.01)

**H04L 29/06** (2006.01)

(52) **U.S. Cl.**

CPC ..... **H04L 47/70** (2013.01); **H04L 47/828** (2013.01); **H04L 69/08** (2013.01); **H04L 69/16** (2013.01)

(58) **Field of Classification Search**

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See application file for complete search history.

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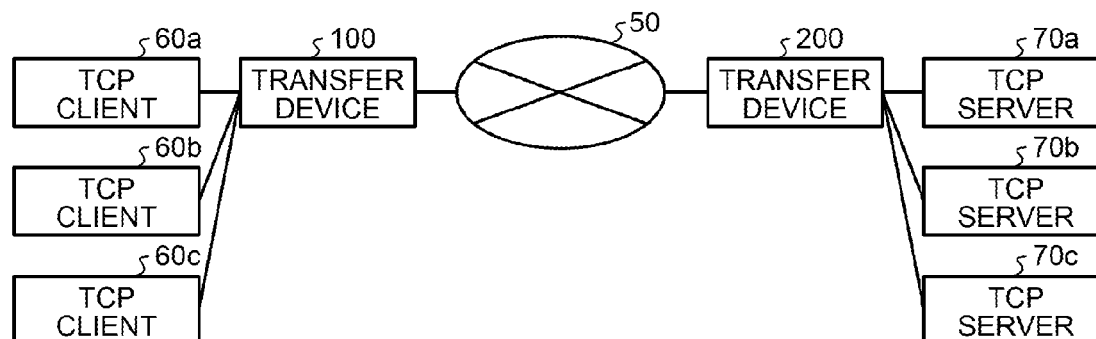
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(57)

#### ABSTRACT

A transfer device allocates, within the range of the maximum communication band of a network that a plurality of groups of applications use in common, a communication band equal to or larger than the minimum band for each of the groups. Furthermore, the transfer device converts, within a communication band allocated to each group, TCP data received from a transmission source of data to UDP data, transfers the UDP data to a transmission destination, and retransmits retransmission data in response to a retransmission request of the UDP data.

**9 Claims, 12 Drawing Sheets**



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FIG.1

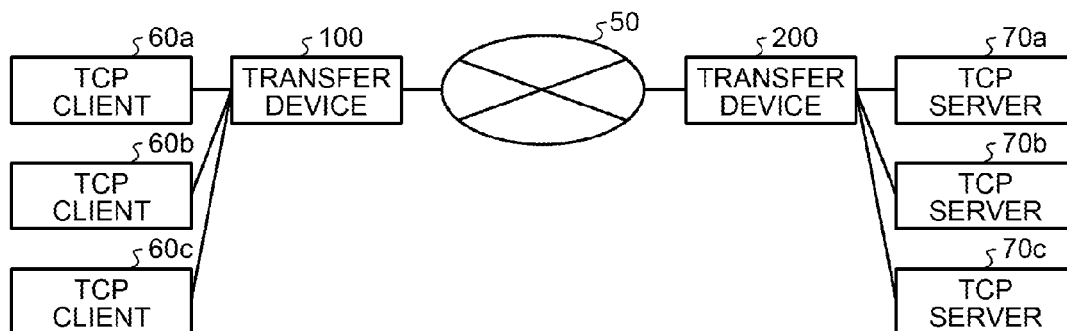


FIG.2

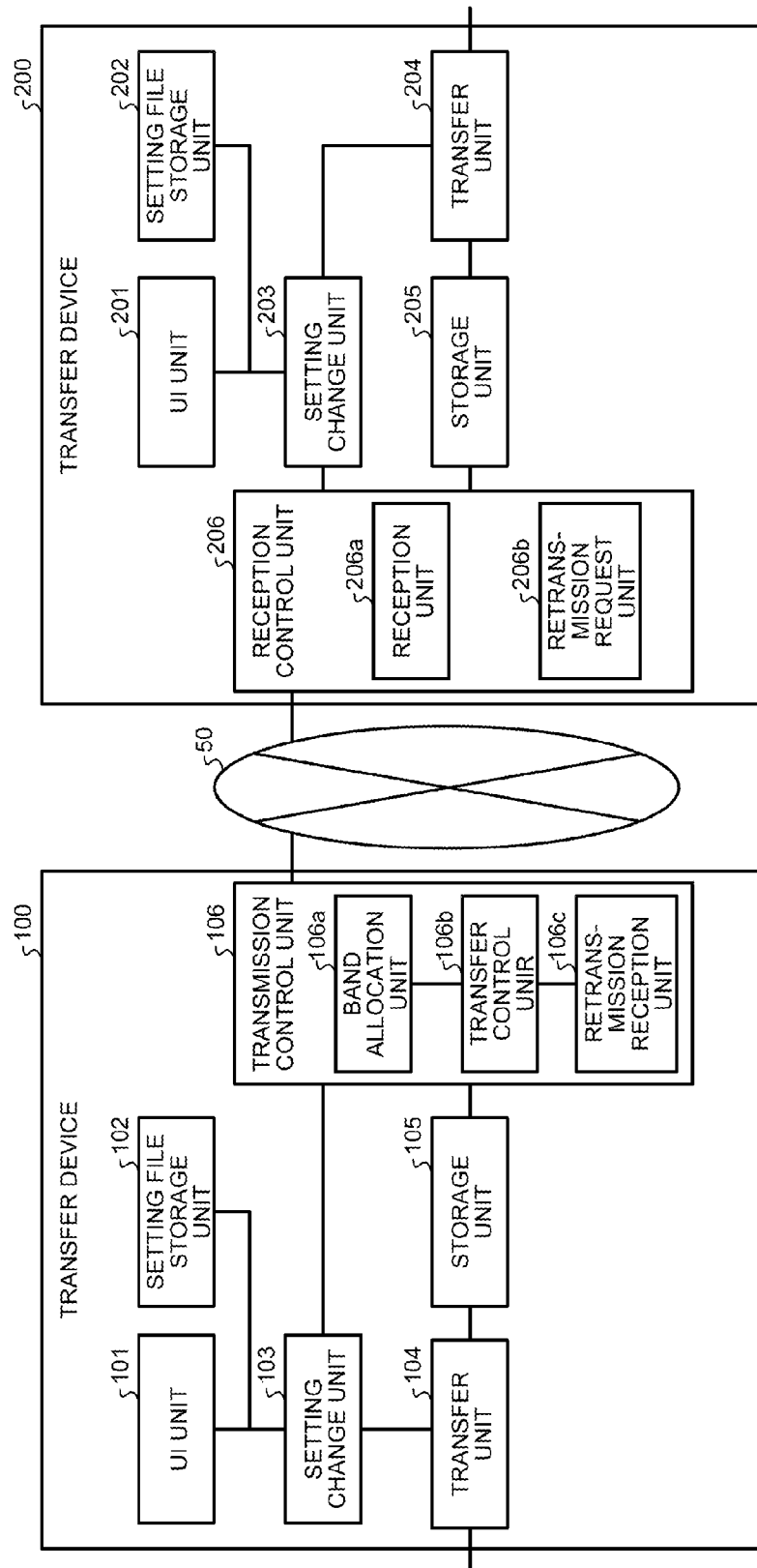


FIG.3

§ 105

IDENTIFICATION NUMBER	TCP PACKET	DATA SIZE T(X)	DATA SIZE R(X)
1	DATA OF TCP PACKET	T(1)	R(1)
2	DATA OF TCP PACKET	T(2)	R(2)
3	DATA OF TCP PACKET	T(3)	R(3)
...			
N	DATA OF TCP PACKET	T(N)	R(N)

FIG.4

UDP HEADER	RPS HEADER	TRANSMISSION DATA PART
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FIG.5

UDP HEADER	RPS HEADER	SendReqID	CurSendOffset
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FIG.6

UDP HEADER	RPS HEADER	Send ReqID	CurSend Offset	Loss Cnt	SackID	Sack MaxID	Ack Data
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FIG. 7

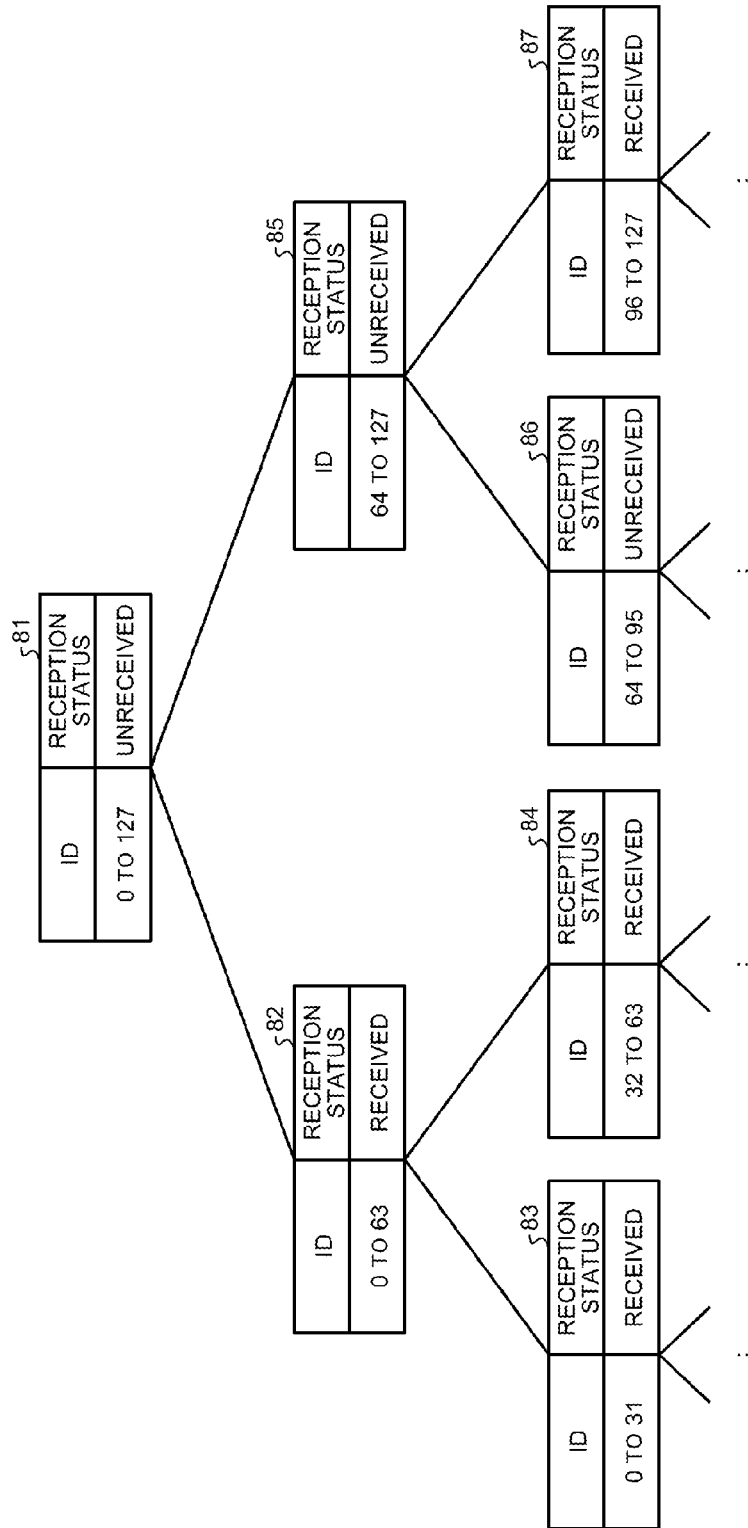


FIG. 8

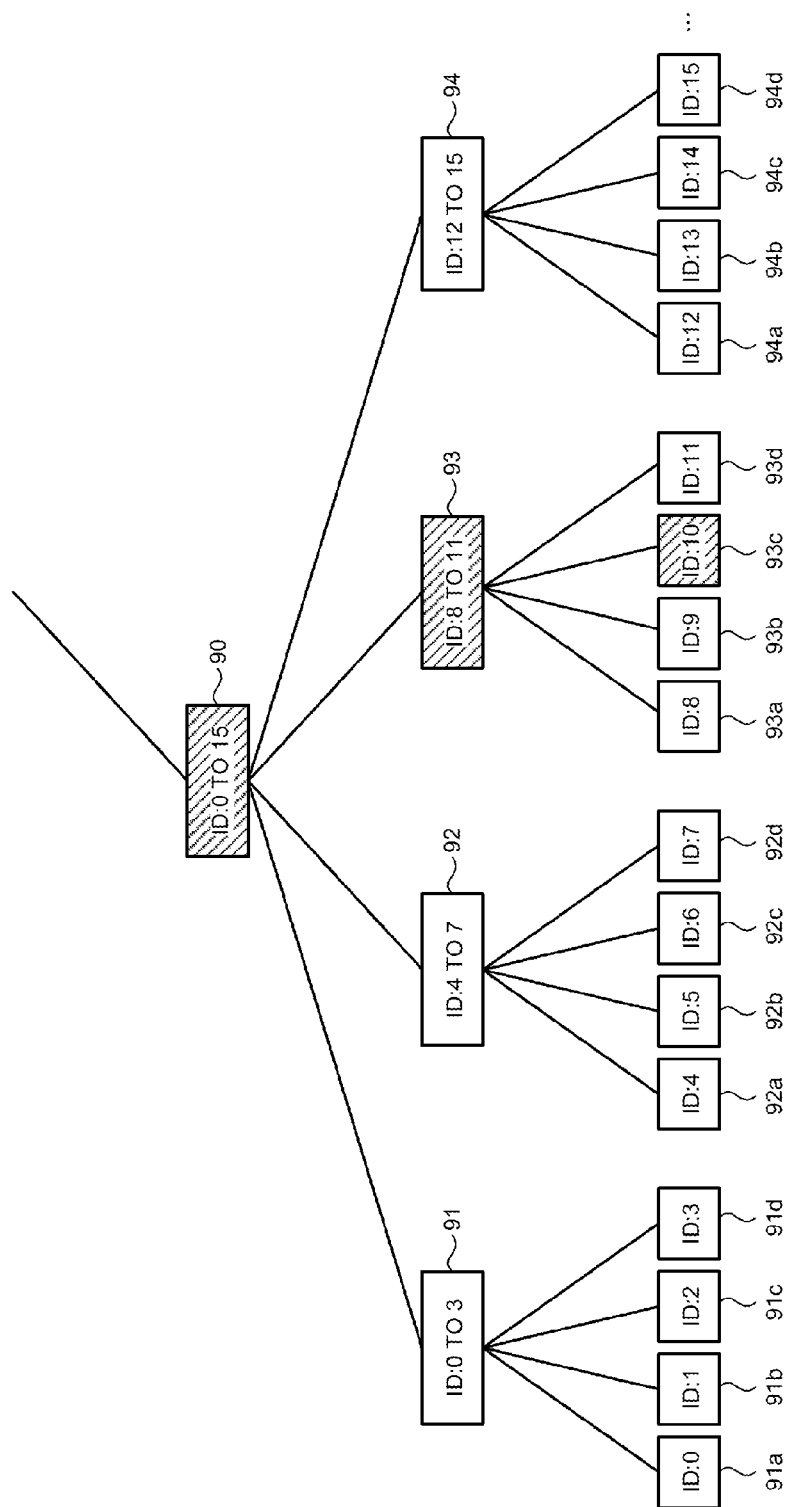




FIG. 9

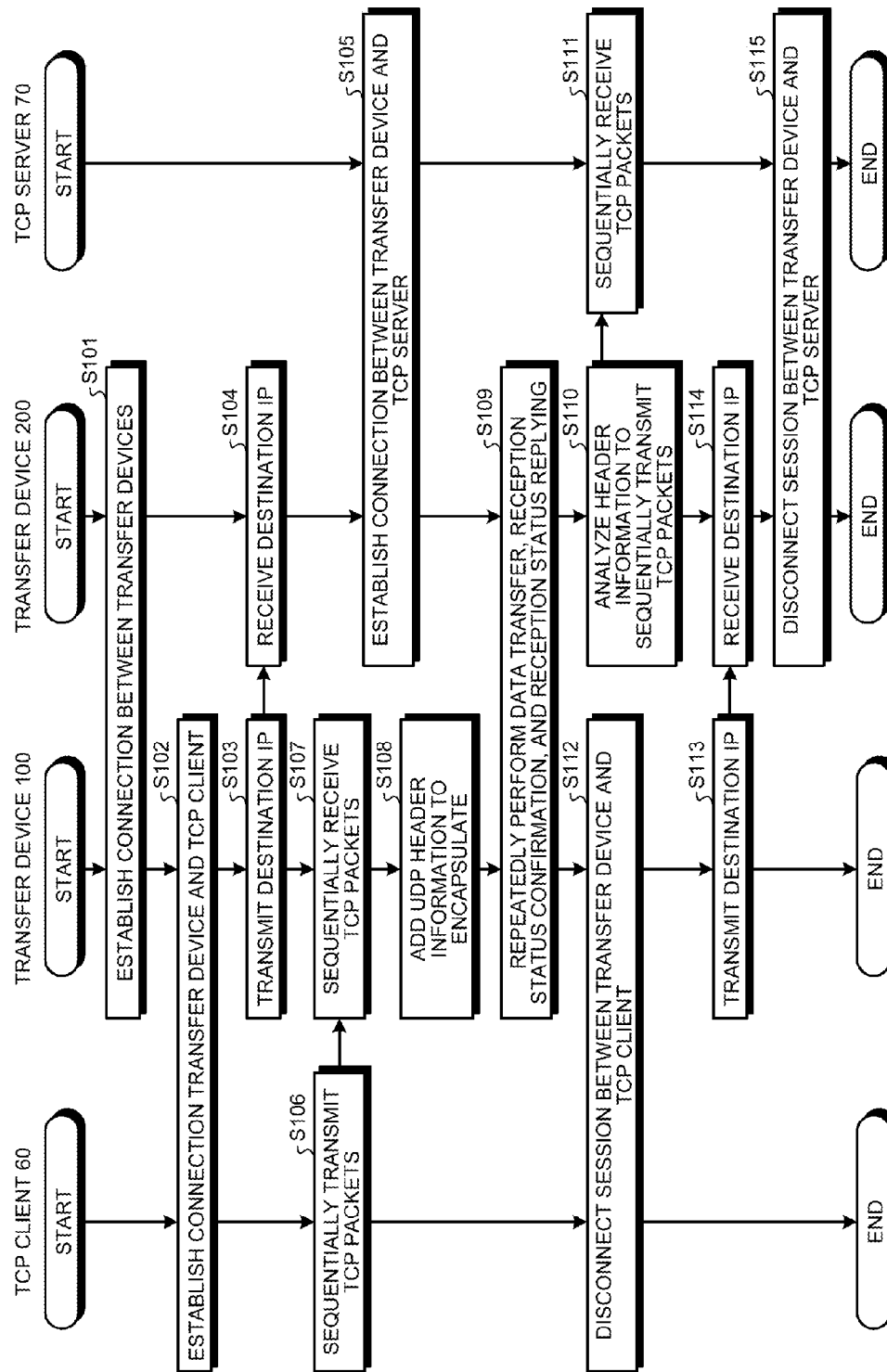


FIG. 10

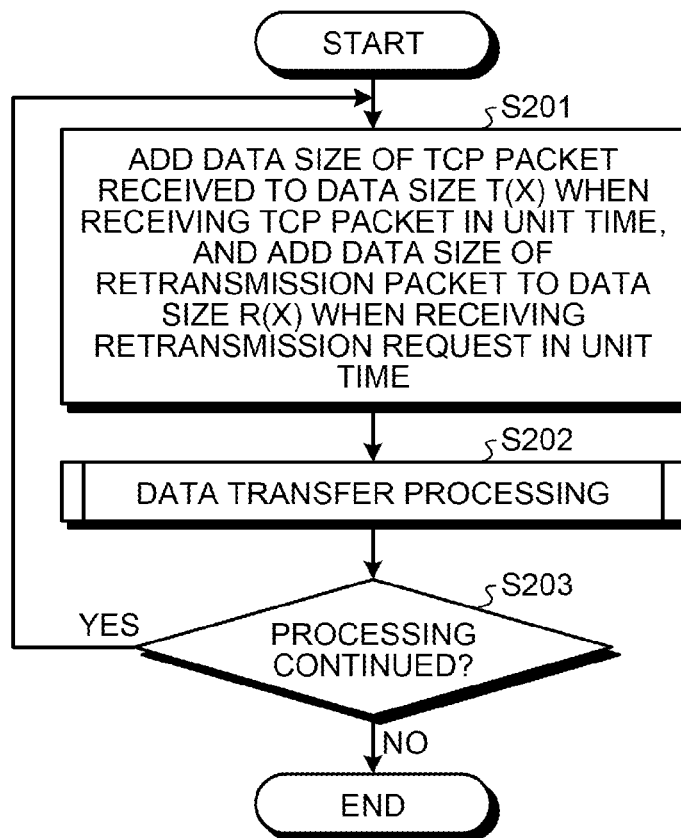


FIG.11

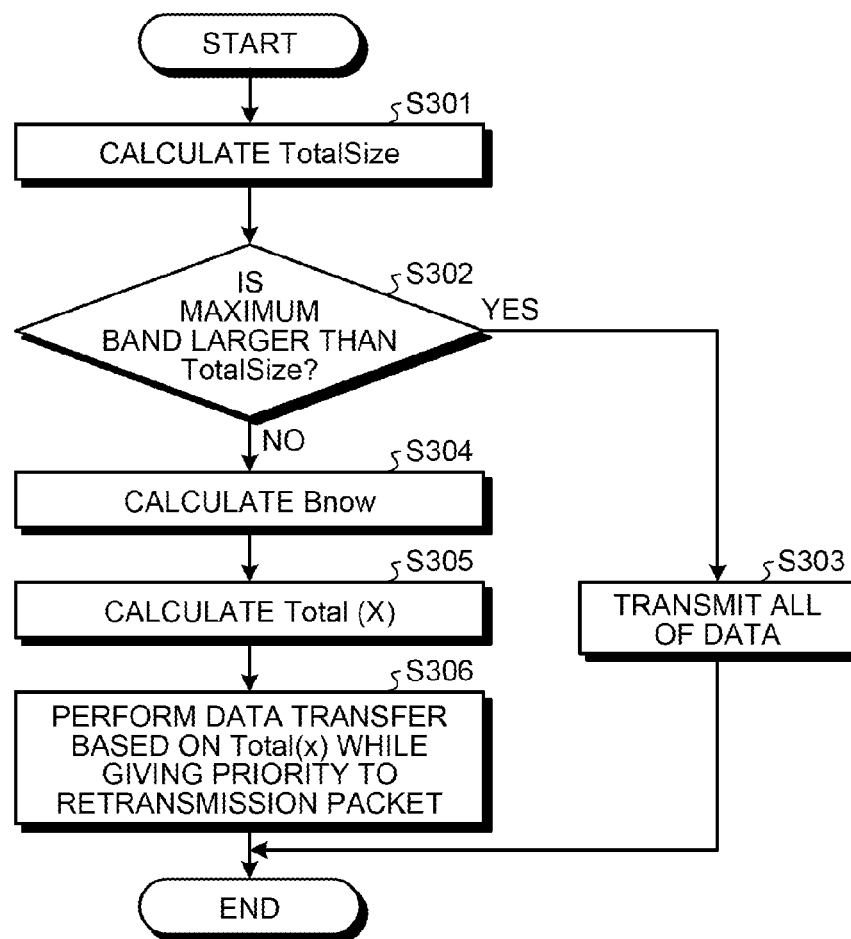


FIG.12

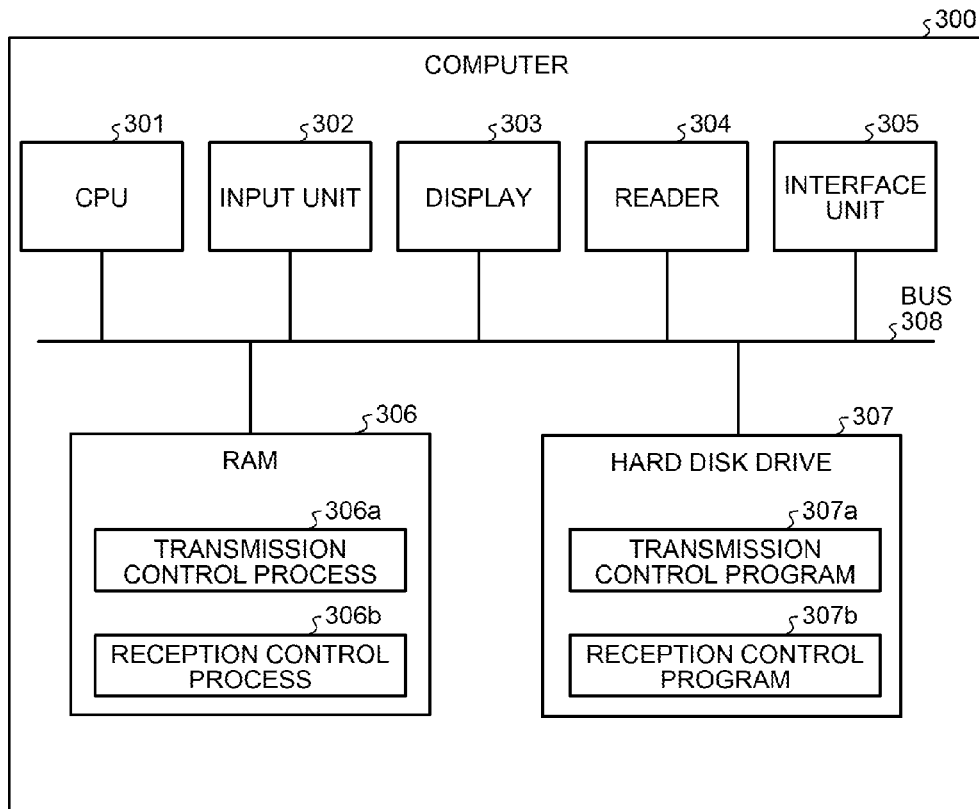


FIG.13

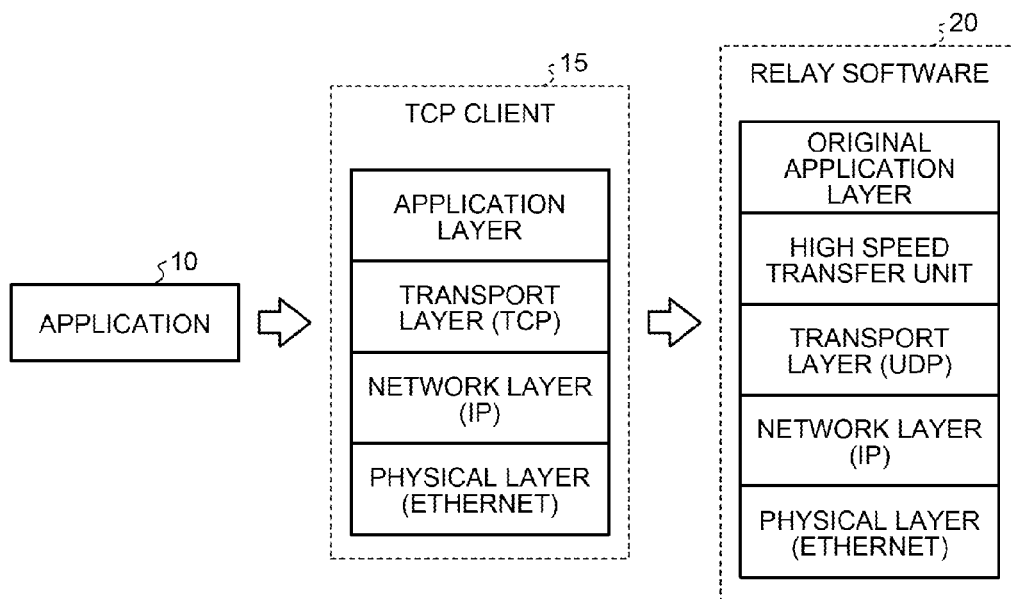
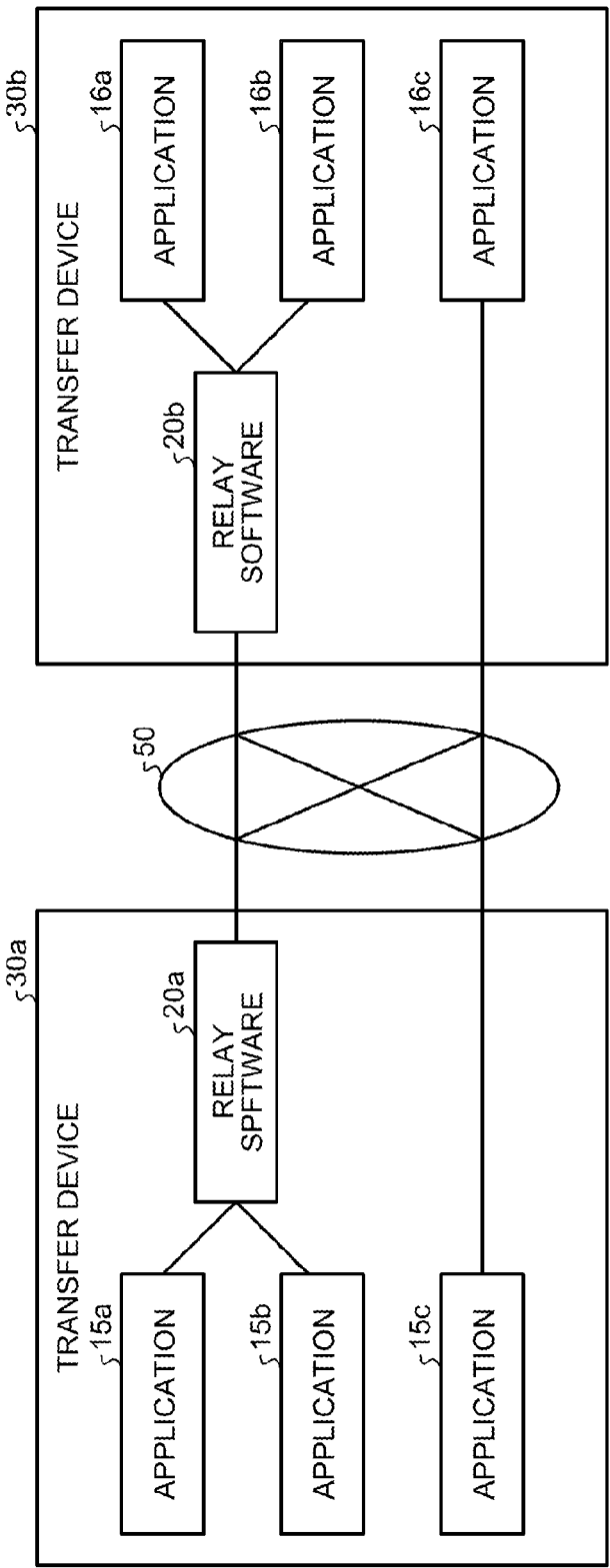


FIG.14



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TRANSFER DEVICE, AND TRANSFER  
METHODCROSS-REFERENCE TO RELATED  
APPLICATION

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2012-190631, filed on Aug. 30, 2012, the entire contents of which are incorporated herein by reference.

## FIELD

The embodiment discussed herein is related to a transfer device or the like.

## BACKGROUND

In recent years, there has existed cloud computing in which a plurality of applications are collaboratively operated on a network thus providing services to users.

In a computer network, for the reliability of data communication, a connection-oriented protocol typified by a transmission control protocol (TCP) is generally used. However, when each application uses the TCP to perform data communication, processing for establishing connection in a handshake process or processing for the acknowledgement of data transfer occurs; for example, when a communication range is long, there exists a case that delay occurs even when a network band is sufficient.

To prevent the occurrence of the delay, there exists a conventional technique substituted for the TCP. FIG. 13 is a view for explaining one example of the conventional technique. In the example illustrated in FIG. 13, an application 10 transmits data to a TCP client 15, and the TCP client 15 transmits a TCP packet to relay software 20.

The relay software 20 captures the TCP packet and converts the TCP packet into a user datagram protocol (UDP) that is a connectionless protocol and a retransmission algorithm to perform data transfer. To be more specific, the relay software 20 converts the TCP packet to a UDP packet to perform data transfer by the UDP. Furthermore, the relay software 20 divides an application layer in two and provides a high-speed transfer unit provided with a retransmission algorithm for performing recovery for dealing with missed data by the UDP or band control. These related-art examples are described, for example in Japanese Laid-open Patent Publication No. 2009-49506.

However, in the above-mentioned conventional technique, there has been a drawback that a communication band is not sufficiently allocated to a group of applications with a smaller amount of data communication, thus causing congestion in retransmission of data.

FIG. 14 is a view for explaining a drawback in the conventional technique. In an example illustrated in FIG. 14, transfer devices 30a and 30b are connected to each other via a network 50. The transfer device 30a has applications 15a, 15b, and 15c, and relay software 20a. The transfer device 30b has applications 16a, 16b, and 16c, and relay software 20b.

For example, the application 15a is a low performance application whose amount of data communication is small and uses the relay software 20a and 20b to perform data communication with the application 16a. The application 15b is a high performance application whose amount of data communication is large and uses the relay software 20a and 20b to perform data communication with the application

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16b. The application 15c is a low performance application whose amount of data communication is small and performs data communication with the application 16c. The relay software 20a or 20b corresponds to the relay software 20 illustrated in FIG. 13.

The conventional relay software 20a or 20b allocates a communication band depending on the performance of each application without considering the maximum communication band of the network 50. Therefore, there exists the case that the relay software 20a or 20b allocates a large communication band to a group of the high performance applications 15b and 16b. In this manner, when the relay software 20a or 20b allocates a communication band to each application, the communication band of the network 50 is occupied, and sufficient communication band is not allocated between the applications 15a and 16a or between the applications 15c and 16c thus causing congestion in retransmission of data.

## SUMMARY

According to an aspect of an embodiment, a transfer device includes a band allocation unit that allocates, within the range of the maximum communication band of a communication line that a plurality of groups of transmission sources and transmission destinations of data use in common, the minimum communication band to each of the groups; and a transfer control unit that, within the communication band allocated to each group by the band allocation unit, converts the data to conversion data transmitted and received with a protocol different from that with which data is received from the corresponding transmission source, transfers the conversion data to the corresponding transmission destination, and retransmits retransmission data in response to a retransmission request of the conversion data.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a view illustrating a constitution of a system according to the present embodiment;

FIG. 2 is a functional block diagram illustrating a constitution of a transfer device in the present embodiment;

FIG. 3 is a view illustrating one example of a data structure of a storage unit in the present embodiment;

FIG. 4 is a view illustrating one example of a data structure of a UDP packet generated by a transfer control unit;

FIG. 5 is a view illustrating one example of a data structure of a reception status confirmation packet;

FIG. 6 is a view illustrating one example of a data structure of a reception status response packet;

FIG. 7 is a view illustrating one example of a data structure of packet reception information in the present embodiment;

FIG. 8 is a view illustrating one example of processing for generating the packet reception information;

FIG. 9 is a flowchart illustrating processing procedures in a system in the present embodiment;

FIG. 10 is a flowchart illustrating processing procedures of data transfer in the present embodiment;

FIG. 11 is a flowchart illustrating procedures of data transfer processing;

FIG. 12 is a view illustrating one example of a computer that executes a transfer program;

FIG. 13 is a view for explaining one example of a conventional technique; and

FIG. 14 is a view for explaining the problem in the conventional technique.

#### DESCRIPTION OF EMBODIMENT

Preferred embodiments of the present invention will be explained with reference to accompanying drawings. Here, the present invention is not limited to the embodiment.

Next, a system according to the present embodiment is explained. FIG. 1 is a view illustrating a constitution of the system in the present embodiment. As illustrated in FIG. 1, the system has TCP clients **60a**, **60b**, and **60c**, TCP servers **70a**, **70b**, and **70c**, and transfer devices **100** and **200**. Here, as one example, the TCP clients **60a** to **60c** and the TCP servers **70a** to **70c** are illustrated; however, other TCP clients or TCP servers may be connected. In explanations below, the TCP clients **60a** to **60c** are referred to collectively as a TCP client **60**. The TCP servers **70a** to **70c** are referred to collectively as a TCP server **70**.

The TCP client **60** is connected to the transfer device **100**. The TCP server **70** is connected to the transfer device **200**. The transfer device **100** and the transfer device **200** are connected to each other via a network **50**. The TCP client **60** and the TCP server **70** execute data communication via the transfer devices **100** and **200**.

The constitutions of the transfer devices **100** and **200** illustrated in FIG. 1 are explained. FIG. 2 is a functional block diagram illustrating the constitutions of the transfer devices according to the present embodiment. As illustrated in FIG. 2, the transfer device **100** has a user interface (UI) unit **101**, a setting file storage unit **102**, a setting change unit **103**, a transfer unit **104**, a storage unit **105**, and a transmission control unit **106**. The transfer device **200** has a UI unit **201**, a setting file storage unit **202**, a setting change unit **203**, a transfer unit **204**, a storage unit **205**, and a reception control unit **206**.

First of all, the constitution of the transfer device **100** is explained. The UI unit **101** is an input unit by which a user inputs various kinds of information. For example, the UI unit **101** corresponds to an input device such as a keyboard or a touch panel. The user operates the UI unit **101** to input various kinds of setting information. The various kinds of setting information input from the UI unit **101** are stored in the setting file storage unit **102**.

The setting file storage unit **102** is a storage unit for storing therein the various kinds of setting information. The setting change unit **103** is a processing unit for properly changing the setting of the transfer unit **104** or the transmission control unit **106** based on the setting information stored in the setting file storage unit **102**.

The transfer unit **104** is a processing unit that establishes connection with the TCP client **60** and receives a TCP packet from the TCP client **60**. The transfer unit **104** stores the TCP packet in the storage unit **105**. The transfer unit **104** stores the TCP packet in the storage unit **105** for each TCP client **60**. Furthermore, the transfer unit **104** stores a data size per unit time of the TCP packet received from the TCP client **60** in the storage unit **105**.

The storage unit **105** is a storage device that stores therein a TCP packet. FIG. 3 is a view illustrating one example of a data structure of a storage unit in the present embodiment.

As illustrated in FIG. 3, the storage unit **105** stores therein an identification number, a TCP packet, a data size  $T(X)$ , and a data size  $R(X)$  that are associated with each other. The identification number indicates information for uniquely identifying a group of the TCP client **60** and the TCP server **70** that perform data communication. The TCP packet indicates data of a TCP packet received from the TCP client **60**. The data size  $T(X)$  indicates a total size of the TCP packets per unit time. The data size  $R(X)$  indicates a total size of retransmission packets retransmitted to the transfer device **200** per unit time. The retransmission packet is a UDP packet subject to a retransmission request from the transfer device **200** that is a transmission destination.

The transmission control unit **106** is a processing unit that converts a TCP packet to a UDP packet and performs data transfer by using the UDP packet. Furthermore, the transmission control unit **106** performs recovery of missed data by a UDP and band control between a TCP client and a TCP server. The transmission control unit **106** has a band allocation unit **106a**, a transfer control unit **106b**, and a retransmission reception unit **106c**.

The band allocation unit **106a** is a processing unit that allocates a communication band equal to or larger than the minimum band to each group of the TCP client **60** and the TCP server **70**. To be more specific, the band allocation unit **106a** calculates, as mentioned below, a band to be allocated to each group of the TCP client **60** and the TCP server **70**. The band allocation unit **106a** outputs calculation results to the transfer control unit **106b**.

Here, processing of the band allocation unit **106a** is specifically explained. First, the band allocation unit **106a** refers to the storage unit **105** and calculates TotalSize based on an expression (1). The TotalSize is a total value of data amounts per unit time in the data communication between the TCP client **60** and the TCP server **70**.

$$\text{TotalSize} = T(1) + \dots + T(N) + R(1) + \dots + R(N) \quad (1)$$

The band allocation unit **106a** compares the maximum band of the network **50** with the TotalSize and determines whether or not the maximum band is larger than the TotalSize. For example, the information of the maximum band is set in advance by a user.

The case that the maximum band is larger than the TotalSize is explained. The band allocation unit **106a** notifies the transfer control unit **106b** that all of data are to be transmitted.

The case that the maximum band is equal to or smaller than the TotalSize is explained. The band allocation unit **106a** refers to the storage unit **105** and calculates "Bnow" based on an expression (2). In the expression (2),  $B(\text{bps})$  is the maximum band of the network **50**, and  $b(\text{bps})$  is the minimum band to be allocated to each group of the TCP client **60** and the TCP server **70**. The value of the minimum band  $b$  is, for example, set in advance by a user. Here, in the expression (2),  $\min(b, R(x))$  is a function that selects a value of smaller one out of  $b$  and  $R(x)$ . That is, it is reasonable to say that "Bnow" is a remaining band value obtained by subtracting a total value of minimum bands to be allocated to the respective groups of the TCP clients **60** and the TCP servers **70** from the maximum band value.

$$\text{Remaining band}(B_{\text{now}}) = B - \sum(\min(b, R(x))) \quad (2)$$

The band allocation unit **106a** calculates "Bnow" and, thereafter, calculates "Total(X)" of each group based on the expression (3). The "Total(X)" is a band to be allocated to each group of the TCP client **60** and the TCP server **70** when the UDP packet and the retransmission packet are transmit-



ted. For example, Total(1) indicates a band to be allocated to a group of the TCP client **60** and the TCP server **70**. The band allocation unit **106a** notifies the transfer control unit **106b** of the information of the "Total(X)" as a calculation result.

$$\text{Total}(X) = \min(b, R(x)) + B \times \text{now} \times (T(X) + R(X)) / \text{TotalSize} \quad (3)$$

The transfer control unit **106b** is a processing unit that establishes connection with the transfer device **200**, converts a TCP packet to a UDP packet, and transmits the UDP packet to the transfer device **200**. For example, the transfer control unit **106b** encapsulates the TCP packet and imparts a UDP header thereto and thus generates a UDP packet. Furthermore, the transfer control unit **106b** stores the UDP packet in the storage unit **105** in preparation for a retransmission. The transfer control unit **106b** transmits, when receiving a retransmission request, a retransmission packet to the transfer device **200** in priority to an untransmitted UDP packet.

FIG. **4** is a view illustrating one example of a data structure of a UDP packet generated by a transfer control unit. As illustrated in FIG. **4**, for example, the UDP packet includes a UDP header, an RPS header, and a transmission data part. The RPS header includes an offset of transmission data and an offset of data whose reception completion notice is received. Furthermore, the UDP header includes an identification (ID) for uniquely identifying the UDP packet. In addition, the transmission data part includes a TCP packet encapsulated.

Processing when the transfer control unit **106b** acquires, from the band allocation unit **106a**, information that all of data are transmitted is explained. The transfer control unit **106b** converts a TCP packet stored in the storage unit **105** to a UDP packet and transmits the converted UDP packet to the transfer device **200**. Furthermore, the transfer control unit **106b** extracts, when acquiring the ID of the UDP packet to be retransmitted from the retransmission reception unit **106c**, the UDP packet to be retransmitted from the storage unit **105** and retransmits the UDP packet to the transfer device **200**. The UDP packet to be retransmitted corresponds to the above-mentioned retransmission packet.

Processing when the transfer control unit **106b** acquires the Total(X) of each group is explained. The transfer control unit **106b** performs processing for transmitting a retransmission packet to the transfer device **200** in priority to an untransmitted UDP packet. The transfer control unit **106b** calculates, based on an expression (4), a remaining band when preferentially transmitting the retransmission packet, converts a TCP packet to a UDP packet, and transmits the UDP packet in the range of the remaining band calculated.

For example, a band to be allocated to a group of the TCP client **60a** and the TCP server **70a** is designated as Total(1) that is set to 100M(bps). Furthermore, T(1) is set to 60M(bps), and R(M) is set to 60M(bps). In this case, the transfer control unit **106b** allocates 60M(bps) out of 100 M(bps) of the Total(1) to the data transfer of the retransmission packet, and allocates remaining 40M(bps) to the data transfer of the untransmitted UDP packet.

In this manner, the transfer control unit **106b** preferentially transmits the retransmission packet and thus supplies UDP packets that have not arrived at the transfer device **200** in order from a temporally older packet. For example, it is possible to fix the problem such that a temporally new UDP packet can be received whereas a temporally old UDP packet which is subjected to a retransmission request is not indefinitely received.

$$\text{Total}(X) - R(X) \quad (4)$$

The retransmission reception unit **106c** is a processing unit that receives an ID of a UDP packet to be retransmitted from the transfer device **200**. For example, the retransmission reception unit **106c** transmits a reception status confirmation packet to the transfer device **200** and receives a reception status response packet that is a response to the reception status confirmation packet. The reception status response packet includes the ID of the UDP packet to be retransmitted.

FIG. **5** is a view illustrating one example of a data structure of the reception status confirmation packet. As illustrated in FIG. **5**, the reception status confirmation packet includes a UDP header, an RPS header, a SendReqID, and a CurSendOffset. The SendReqID indicates the number of reception status responses received. The CurSendOffset indicates a position from the head of data transmitted.

FIG. **6** is a view illustrating one example of a data structure of the reception status response packet. As illustrated in FIG. **6**, the reception status response packet includes a UDP header, an RPS header, a SendReqID, and a CurSendOffset. Furthermore, the reception status response packet includes a LossCnt, a SackID, a SackMaxID, and an AckData. The LossCnt indicates the total number of packets received. The SackID indicates the number of the AckData included in the reception status response packet. The SackMaxID indicates the total number of the AckData. The AckData includes a start ID and an end ID of the UDP packet received. For example, the retransmission reception unit **106c** refers to the AckData and thus identifies the ID of the UDP packet to be retransmitted.

The retransmission reception unit **106c** outputs the ID of the retransmission packet to the transfer control unit **106b**. Furthermore, the retransmission reception unit **106c** adds the amount of data per unit time of the retransmission packet to the R(X) and updates the storage unit **105**.

Next, the constitution of the transfer device **200** is explained. The UI unit **201** is an input unit by which a user inputs various kinds of information. For example, the UI unit **201** corresponds to an input device such as a keyboard or a touch panel. The user operates the UI unit **201** to input various kinds of information. Various kinds of setting information input from the UI unit **201** are stored in the setting file storage unit **202**.

The setting file storage unit **202** is a storage device that stores therein various kinds of setting information. The setting change unit **203** is a processing unit that properly changes the setting of the transfer unit **204** or the reception control unit **206** based on the setting information stored in the setting file storage unit **202**.

The transfer unit **204** is a processing unit that establishes the connection with the TCP server **70** and transfers a TCP packet stored in the storage unit **205** to the TCP server **70**.

The storage unit **205** stores therein a TCP packet corresponding to each group of the TCP client **60** and the TCP server **70**. Furthermore, the storage unit **205** stores therein packet reception information. The packet reception information is information used for determining an unreceived UDP packet.

FIG. **7** is a view illustrating one example of a data structure of packet reception information according to the present embodiment. As illustrated in FIG. **7**, the packet reception information has a tree-shaped structure constituted of nodes **81** to **87**. In each of the nodes **81** to **87**, an ID for uniquely identifying a UDP packet and a reception status are associated with each other. The node **81** is connected to the nodes **82** and **85**. The node **82** is connected to the nodes **83** and **84**. The node **85** is connected to the nodes **86** and **87**.

In FIG. 7, in the node **81**, the reception status is “unreceived”. Accordingly, the node **81** indicates that any UDP packet out of UDP packets identified by the IDs 0 to 127 is not received.

In the node **82**, the reception status is “received”. Accordingly, the node **82** indicates that UDP packets identified by IDs 0 to 63 are all received. In the node **83**, the reception status is “received”. Accordingly, the node **83** indicates that UDP packets identified by IDs 0 to 31 are all received. In the node **84**, the reception status is “received”. Accordingly, UDP packets identified by IDs 32 to 63 are all received.

In the node **85**, the reception status is “unreceived”. Accordingly, the node **85** indicates that any UDP packet out of UDP packets identified by IDs 64 to 127 is not received. In the node **86**, the reception status is “unreceived”. Accordingly, the node **86** indicates that any UDP packet out of UDP packets identified by IDs 64 to 95 is not received. In the node **87**, the reception status is “received”. Accordingly, the node **87** indicates that UDP packets identified by IDs 96 to 127 are all received. In the nodes each of which has packet reception information, by tracing each node in which the reception status is “unreceived”, the ID of an unreceived UDP packet can be identified.

The reception control unit **206** receives a UDP packet from the transfer device **100**, converts the UDP packet to a TCP packet, and sequentially stores the TCP packet in the storage unit **205**. Furthermore, the reception control unit **206** transmits the information of an unreceived UDP packet to the transfer device **100** and requests retransmission of the unreceived UDP packet. The reception control unit **206** has a reception unit **206a** and a retransmission request unit **206b**.

The reception unit **206a** receives a UDP packet from the transfer unit, converts the UDP packet received to a TCP packet, and sequentially stores the TCP packet in the storage unit **205**. For example, the reception unit **206a** extracts an encapsulated TCP packet included in the UDP packet and stores the TCP packet in the storage unit **205**. Furthermore, the reception unit **206a** generates the packet reception information illustrated in FIG. 7 based on the ID included in the UDP packet.

Here, one example of processing in which the reception unit **206a** generates packet reception information is explained. FIG. 8 is a view illustrating one example of processing for generating the packet reception information. In FIG. 8, illustrations of reception statuses are omitted. As illustrated in FIG. 8, the reception unit **206a** receives UDP packets of IDs 0 to 3 and, thereat, generates nodes **91a** to **91d** corresponding to the IDs 0 to 3 and sets the reception status of each of the nodes **91a** to **91d** to “received”. Furthermore, the reception unit **206a** generates a node **91** and sets a status that the UDP packets of the IDs 0 to 3 have been received to the node **91**.

The reception unit **206a** receives UDP packets of IDs 4 to 7 and, thereat, generates nodes **92a** to **92d** corresponding to the IDs 4 to 7 and sets the reception status of each of the nodes **92a** to **92d** to “received”. Furthermore, the reception unit **206a** generates a node **92** and sets a status that the UDP packets of the IDs 4 to 7 have been received to the node **92**.

The reception unit **206a** receives UDP packets of IDs 8, 9, and 11 and, thereat, generates nodes **93a** to **93d** corresponding to IDs 8 to 11, and sets the reception status of each of the nodes **93a**, **93b**, and **93d** to “received”. The reception unit **206a** sets, since the UDP packet of the ID 10 is not received, the reception status of the node **93c** to “unreceived”. Furthermore, the reception unit **206a** generates a node **93** and sets the reception status corresponding to each of the IDs 8 to 11 to “unreceived”. The reception unit **206a**

receives UDP packets of IDs 12 to 15 and, thereat, generates nodes **94a** to **94d** corresponding to the IDs 12 to 15 and sets the reception status of each of the nodes **94a** to **94d** to “received”. Furthermore, the reception unit **206a** generates a node **94** and sets a status that the UDP packets of the IDs 12 to 15 have been received to the node **94**.

The reception unit **206a** generates the nodes **91** to **94** and, thereafter, generates a node **90**. The reception unit **206a** sets, since the reception status of the node **93** is “unreceived”, the reception status corresponding to each of the IDs 0 to 15 to “unreceived”. The reception unit **206a** repeatedly performs the above-mentioned processing every time when receiving the UDP packet and thus generates the packet reception information.

The retransmission request unit **206b** receives a reception status confirmation packet from the transfer device **100**, identifies an ID of an unreceived UDP packet based on the packet reception information in the storage unit **205**, and notifies the transfer device **100** of the ID identified and thus requests retransmission of the unreceived UDP packet. The retransmission request unit **206b** traces, among the nodes each of which has packet reception information, each node in which the reception status is “unreceived” and thus identifies the ID of an unreceived UDP packet. The retransmission request unit **206b** generates the reception status response packet and transmits the packet to the transfer device **100**. For example, in the example illustrated in FIG. 8, the retransmission request unit **206b** identifies, when tracing each node in which the reception status is “unreceived”, the node **93** and thus determines that the UDP packet of the ID 10 is not received.

Next, processing procedures of the system according to the present embodiment is explained. FIG. 9 is a flowchart illustrating processing procedures in the system according to the present embodiment. As illustrated in FIG. 9, connection between the transfer device **100** and the transfer device **200** is established (S101). Connection between the TCP client **60** and the transfer device **100** is established (S102).

The transfer device **100** transmits a destination IP to the transfer device **200** (S103), and the transfer device **200** receives the destination IP (S104). In S103 and S104, the destination IP corresponds to the IP address of the TCP server **70** with which the TCP client **60** performs data communication.

A connection between the transfer device **200** and the TCP server **70** is established (S105). The TCP client **60** sequentially transmits TCP packets (S106), and the transfer device **100** sequentially receives the TCP packets (S107).

The transfer device **100** adds a UDP header to a TCP packet to encapsulate the TCP packet (S108). The transfer device **100**, together with the transfer device **200**, repeatedly performs data transfer, reception status confirmation, and reception status replying of a UDP packet or a retransmission packet (S109). In S109, the transfer device **100** calculates a band to be allocated to a group of the TCP client **60** and the TCP server **70** and performs data transfer within the band calculated.

The transfer device **200** analyzes header information to sequentially transmit a TCP packet to the TCP server **70** (S110), and the TCP server **70** sequentially receives the TCP packet (S111). After the completion of TCP-packet transfer from the TCP client **60**, a session between the TCP client **60** and the transfer device **100** is disconnected (S112).

The transfer device **100** transmits a destination IP to the transfer device **200** (S113), and the transfer device **200** receives the destination IP (S114). In S113 and S114, the destination ID corresponds to the IP address of the TCP

server **70** with which the TCP client **60** finishes data communication. A session between the transfer device **200** and the TCP server **70** is disconnected (S115). Next, processing procedures by which the transfer device **100** performs data transfer is explained. FIG. **10** is a flowchart illustrating processing procedures of data transfer according to the present embodiment. For example, the processing illustrated in FIG. **10** is performed at a time when the transfer device **100** starts the reception of a TCP packet from the TCP client **60**.

As illustrated in FIG. **10**, the transfer device **100** adds, when receiving a TCP packet in a unit time, the data size of the TCP packet received to the data size  $T(X)$ . Furthermore, the transfer device **100** adds, when receiving a retransmission request in a unit time, the data size of the retransmission packet to the data size  $R(X)$  (S201).

The transfer device **100** performs data transfer processing (S202) and, when continuing processing (Yes at S203), advances the processing to S201 again. On the other hand, the transfer device **100** finishes the processing when discontinuing the processing (No at S203). That is, the transfer device **100** repeatedly performs, while continuing the processing, processing in S201 and S202 for every predetermined unit time.

Next, the data transfer processing in S202 illustrated in FIG. **10** is explained. FIG. **11** is a flowchart illustrating processing procedures of the data transfer processing. As illustrated in FIG. **11**, the transfer device **100** calculates TotalSize (S301). In S301, the transfer device **100** calculates TotalSize based on the expression (1).

The transfer device **100** determines whether or not the maximum band is larger than TotalSize (S302). The transfer device **100** transmits, when the maximum band is larger than TotalSize (Yes at S302), all of data (S303).

The transfer device **100** calculates, when the maximum band is not larger than TotalSize (No at S302), Bnow (S304). In S304, the transfer device **100** calculates Bnow based on the expression (2).

The transfer device **100** calculates Total(X) for each group of the TCP client **60** and the TCP server **70** (S305). In S305, the transfer device **100** calculates Total(X) based on the expression (3).

The transfer device **100** performs, based on Total(X), data transfer of a UDP packet and a retransmission packet while giving priority to the retransmission packet (S306).

Next, advantageous effects of the transfer device **100** according to the present embodiment are explained. The transfer device **100** allocates, within the range of the maximum communication band of a communication line that a plurality of groups of applications use in common, a communication band equal to or larger than the minimum band for each of the groups of applications and controls transfer and retransmission of UDP data. Hence, according to the transfer device **100**, it is possible to ensure a communication band that is sufficient for retransmitting the retransmission packet; for example, it is possible to prevent congestion in retransmission of data even in the case of a group of applications with a small amount of data communication.

Furthermore, according to the transfer device **100**, a communication band allocated to each of a plurality of groups of applications is calculated by adding the minimum communication band and a communication band corresponding to the amount of data communication transmitted and received by the group of applications. Hence, according to the transfer device **100**, it is possible to equally allocate a communication band to each group of applications; for example, it is possible to prevent, while operating an appli-

cation using a high band, from disabling data communication by the other application using a low band. Furthermore, it is possible to make full use of available communication bands.

Furthermore, the transfer device **100** preferentially transmits the retransmission packet and performs data transfer of remaining UDP data within the range of a communication band obtained by subtracting a communication band used for transmitting the retransmission packet from the communication band allocated to a group of applications. Accordingly, the retransmission packet can be transferred early and thus supply preferentially a packet lacking in the transfer device **200**.

Furthermore, the transfer device **200** generates packet reception information having a tree-shaped structure based on an ID of a UDP packet received and a reception status. In addition, the transfer device **200** transmits a retransmission request to the transfer device **100** based on the packet reception information. Accordingly, it is possible to identify an ID of an unreceived UDP packet without sequentially confirming the ID of the unreceived UDP packet from a start ID to an end ID. For example, an amount of calculation for identifying the ID of the unreceived UDP packet becomes  $(\log N)$ . This can prevent a phenomenon in which it takes time for an ACK request and a packet queue becomes full, and thus a packet loss increases.

Here, the constitution of the transfer device **100** or **200** is not limited to that illustrated in FIG. **2**. For example, the transfer device **100** may have the function of the reception control unit **206** in the transfer device **200**. Furthermore, the transfer device **200** may have the function of the transmission control unit **106** in the transfer device **100**. Then, the transfer device **200** may receive a TCP packet from the TCP client **60** and perform data transmission to the transfer device **100**, and the transfer device **100** may transmit a TCP packet to the TCP server **70**.

Next, one example of a computer that executes a transfer program capable of providing the function same as that of the transfer device **100** or **200** exemplified in each embodiment is explained. FIG. **12** is a view illustrating one example of a computer that executes a transfer program.

As illustrated in FIG. **12**, a computer **300** has a CPU **301** that executes various kinds of arithmetic processing, an input unit **302** that accepts the input of data from a user, and a display **303**. Furthermore, the computer **300** has a reader **304** that reads out a program or the like from a storage medium, and an interface unit **305** through which data is transmitted to or received from the other computer via a network. In addition, the computer **300** has a RAM **306** that temporarily stores therein various kinds of information, and a hard disk drive **307**. Here, the devices **301** to **307** are respectively connected to a bus **308**.

The hard disk drive **307** has, for example, a transmission control program **307a** and a reception control program **307b**. The CPU **301** reads out each of the programs **307a** and **307b** to load on the RAM **306**.

The transmission control program **307a** functions as a transmission control process **306a**. The reception control program **307b** functions as a reception control process **306b**.

For example, the transmission control process **306a** corresponds to the transmission control unit **106**. The reception control process **306b** corresponds to the reception control unit **206**.

Here, it is unnecessary to store each of the programs **307a** and **307b** in the hard disk drive **307** in advance. For example, each program may be stored in a "portable physical medium" such as a flexible disk (FD), a CD-ROM, a DVD,

a magneto-optical disk, or an IC card, and the computer 300 may read out each of the programs 307a and 307b from the medium to execute each program.

Here, in the processing in the present embodiment, transmission is performed by UDP communication; however, a communication scheme is not limited to the UDP communication. For example, a connectionless communication protocol may be used. The connectionless communication is a communication scheme in data communication such that a transfer device unilaterally transmits data without confirming the status of a communication partner or that transfer devices transmit data to each other in such a manner as above.

The transfer device disclosed in the present invention provides an advantageous effect of preventing congestion in retransmission of data even in the case of a group of applications with a small amount of data communication.

All examples and conditional language recited herein are intended for pedagogical purposes of aiding the reader in understanding the invention and the concepts contributed by the inventor to further the art, and are not to be construed as limitations to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiment of the present invention has been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A transfer device comprising:
  - a processor that executes a process including:
    - calculating a communication band to be allocated to each of groups of transmission sources and transmission destinations, wherein the calculating calculates the communication band according to a bit rate= $\min(b,R)+B_{\text{now}}*(T*R)/\text{TotalSize}$ , the  $\min(b,R)$  being a function that selects a value of smaller one out of b and R, b being a value set by a user, R being a total size of retransmission packets retransmitted to another transfer device, the B<sub>now</sub> being a remaining band value obtained by subtracting a total value of the minimum band value to be allocated to each groups of the transmission sources and the transmission destinations from the maximum band value, the minimum band value and the maximum band being a value set by a user, T being a total size of TCP packets per unit time, TotalSize being a total value of data amounts per unit time in a data communication between a transmission source and a transmission destination;
    - allocating the communication band calculated to the corresponding group;
    - converting, within the communication band allocated to each group, data to conversion data transmitted and received with a protocol different from a protocol with which the data is received from the corresponding transmission source;
    - transferring the conversion data to the corresponding transmission destination; and
    - performing data transfer of retransmission data in response to a retransmission request of the conversion data before transferring remaining conversion data which has not been transmitted to the corresponding transmission destination, within a range of the communication band.
2. The transfer device according to claim 1, the process further comprising:
  - sequentially receiving conversion data from another transfer device, recording identification information for uniquely identifying the conversion data received in the

form of tree-structured data; and identifying conversion data subject to the retransmission request based on the tree-structured data.

3. A transfer method executed by a computer, the transfer method comprising:
  - calculating a communication band to be allocated to each of groups of transmission sources and transmission destinations, wherein the calculating calculates the communication band according to a bit rate= $\min(b,R)+B_{\text{now}}*(T*R)/\text{TotalSize}$ , the  $\min(b,R)$  being a function that selects a value of smaller one out of b and R, b being a value set by a user, R being a total size of retransmission packets retransmitted to another transfer device, the B<sub>now</sub> being a remaining band value obtained by subtracting a total value of the minimum band value to be allocated to each groups of the transmission sources and the transmission destinations from the maximum band value, the minimum band value and the maximum band being a value set by a user, T being a total size of TCP packets per unit time, TotalSize being a total value of data amounts per unit time in a data communication between a transmission source and a transmission destination;
  - allocating the communication band calculated to the corresponding group;
  - converting, within the communication band allocated to each group, data to conversion data transmitted and received with a protocol different from a protocol with which the data is received from the corresponding transmission source;
  - transferring the conversion data to the corresponding transmission destination; and
  - performing data transfer of retransmission data in response to a retransmission request of the conversion data before transferring remaining conversion data which has not been transmitted to the corresponding transmission destination, within a range of the communication band.
4. The transfer method according to claim 3, further comprising:
  - sequentially receiving conversion data from another transfer device, recording identification information for uniquely identifying the conversion data received in the form of tree-structured data, and identifying conversion data subject to the retransmission request based on the tree-structured data.
5. A non-transitory computer-readable recording medium having stored therein a program for causing a computer to execute a transfer process comprising:
  - calculating a communication band to be allocated to each of groups of transmission sources and transmission destinations, wherein the calculating calculates the communication band according to a bit rate= $\min(b,R)+B_{\text{now}}*(T*R)/\text{TotalSize}$ , the  $\min(b,R)$  being a function that selects a value of smaller one out of b and R, b being a value set by a user, R being a total size of retransmission packets retransmitted to another transfer device, the B<sub>now</sub> being a remaining band value obtained by subtracting a total value of the minimum band value to be allocated to each groups of the transmission sources and the transmission destinations from the maximum band value, the minimum band value and the maximum band being a value set by a user, T being a total size of TCP packets per unit time, TotalSize being a total value of data amounts per unit time in a data communication between a transmission source and a transmission destination;
  - allocating the communication band calculated to the corresponding group;

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converting, within the communication band allocated to each group, data to conversion data transmitted and received with a protocol different from a protocol with which the data is received from the corresponding transmission source;

transferring the conversion data to the corresponding transmission destination; and

performing data transfer of retransmission data in response to a retransmission request of the conversion data before transferring remaining conversion data which has not been transmitted to the corresponding transmission destination, within a range of the communication band.

6. The non-transitory computer-readable recording medium according to claim 5, the transfer process causing the computer to further execute:

sequentially receiving conversion data from another transfer device, recording identification information for

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uniquely identifying the conversion data received in the form of tree-structured data, and identifying conversion data subject to the retransmission request based on the tree-structured data.

7. The transfer device according to claim 1, wherein the calculating calculates the communication band according to the bit rate= $\min(b,R)+B_{\text{now}}*(T*R)/\text{TotalSize}$ , when the TotalSize is larger than the maximum band.

8. The transfer method according to claim 3, wherein the calculating calculates the communication band according to the bit rate= $\min(b,R)+B_{\text{now}}*(T*R)/\text{TotalSize}$ , when the TotalSize is larger than the maximum band.

9. The non-transitory computer-readable recording medium according to claim 5, wherein the calculating calculates the communication band according to the bit rate= $\min(b,R)+B_{\text{now}}*(T*R)/\text{TotalSize}$ , when the TotalSize is larger than the maximum band.

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